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UNITED STATES AIR FORCE ARMSTRONG LABORATORY

Health Risk Assessment At Air Force Plant 6, Marietta, GA

Brian L. Sassaman, Captain, USAF
G. Cornell Long

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Occupational and Environmental Health Directorate
Occupational Medicine Division
2402 E Drive
Brooks AFB, TX 78235-5114

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ANDREW T. MACCABE, Maj, USAF, BSC
Chief, Health Risk Assessment Branch

TIMOTHY C. IHRYG, Col, USAF, BSC
Chief, Occupational Medicine Division

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13. ABSTRACT *(Maximum 200 words)*

This report evaluates the potential for health impact from various volatile organic compounds (VOCs) to students at Southern Polytechnical College that may come in cotact with water in Rottenwood Creek. Rottenwood Creek is in part fed by two streams that flow offsite from two retention basins located on Air Force Plant 6 (AFP 6), Marietta, Georgia. The evaluation was requested by Aeronautical System Center/Environmental Management Restoration (ASC/EMR). The evaluation uses the existing Environmental Protection Agency (EPA) "Risk Assessment Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A)", EPA/540/1-89-002. Based on the evaluation, the potential exposure and associated health risks to students are negligible and the water is safe.

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INTRODUCTION

This report evaluated the potential for health impact from various volatile organic compounds (VOCs) to students at Southern Polytechnical College that may come in contact with water in Rottenwood Creek. Rottenwood Creek is in part fed by two streams that flow offsite from two retention basins located on Air Force Plant 6 (AFP 6), Marietta, Georgia. The evaluation uses existing Environmental Protection Agency (EPA) guidance. Based on the evaluation, the potential exposures and associated health risks to students are negligible and the water is safe.

METHODS

Background

Mr. David Brucker of Aeronautical System Center/Environmental Management Restoration (ASC/EMR) requested the Health Risk Assessment Branch at Armstrong Laboratory (AL/OEMH) evaluate exposures to VOCs in water found in Rottenwood Creek. The purpose of performing a risk assessment was to determine the likelihood that people living, working, or playing at or near the site may experience health problems as a result of their exposure to chemicals in the creek. A traditional risk assessment paradigm is composed of four components: **Data Collection and Evaluation, Exposure Assessment, Toxicity Assessment, and Risk Characterization.** Typically, remedial actions use a simplified construct, where: RISK = Toxicity and Exposure. This report attempts to follow the risk assessment paradigm. Since AFP 6 is located in EPA Region IV, the Region IV Supplemental Guidance to Risk Assessment Guidance for Superfund (RAGS) was followed where applicable.

There are two streams that flow offsite from AFP 6 retention basins (Appendix 1). These streams combine into Rottenwood Creek, travel across the college campus, and eventually discharge into the Chatahoochee River. In Jan 95, an irrigation water well and the streams on the campus were tested and found to have elevated levels of VOCs. The Air Force initiated an offsite contaminate groundwater investigation which is currently underway. During a Mar 96 public meeting at AFP 6, the environmental coordinator for the college questioned the safety of the water in Rottenwood Creek. He stated that students occasionally go into the Creek, and he was concerned about the health effect of the contaminants in water on them. The Air Force agreed to conduct a risk assessment to address this issue. A future public meeting for AFP 6 was tentatively scheduled to respond to the question of safety of the water.

Data Collection and Evaluation

Data collection and evaluation attempts to answer the questions, "What are the contaminants of concern?" and "Where is the contamination?" For AFP 6, surface water concentrations collected for Rottenwood Creek and tributaries 1 and 2 in 1994 are

presented in Appendix 2. Chemical concentrations used in the risk assessment are in bold type. The reason for using the bolded concentrations was to identify the contaminants that had the most likely potential for human contact. The most likely point of contact was identified along Rottenwood Creek; therefore, where concentrations were available, concentrations for Rottenwood Creek were used. Where the level was non detect (nd), the highest level from tributary 1 or 2 was used.

Exposure Assessment

Exposure assessment attempts to answer the questions, "How do people come in contact with the contaminants?" and "How much exposure is involved?" The Environmental Protection Agency's Risk Assessment Guidance for Superfund (RAGS) was used for the risk assessment employing a modified adult recreational exposure scenario for the Southern Polytech College student population. In addition, three exposure pathways were calculated: surface water ingestion, surface dermal contact, and ambient air inhalation. Both the carcinogenic (life time average daily dose - LADD) and noncarcinogenic (chronic daily dose - CDD) intakes or doses were calculated using the following equations.

Intake Equation (ingestion)	Intake Equation (dermal)	Intake Equation (inhalation)
$I = \frac{C \times IR \times EF \times ED}{BW \times AT}$	$I = \frac{C \times SA \times PC \times CD \times EF \times 1E\text{-}3}{BW \times AT}$	$I = \frac{C \times IR \times EF \times ED}{BW \times AT}$
I = intake (mg/kg body weight)	I = intake (mg/kg body weight)	I = intake (mg/kg body weight)
C = chemical concentration	C = chemical concentration	C = inhalation rate
IR = ingestion rate	SA = surface area	IR = inhalation rate
EF = exposure frequency	PC = partition coefficient	EF = exposure frequency
ED = exposure duration	EF = exposure frequency	ED = exposure duration
BW = body weight	CD = contact duration	BW = body weight
AT = averaging time	BW = body weight	AT = averaging time
	AT = averaging time	
	1E-3 = conversion factor	

The following tables summarize the exposure assumptions used in the general intake equation, linear low-dose cancer risk equation, and the noncancer hazardous quotient equation.

Adult recreational surface water ingestion			
Ingestion Rate	L/d	0.01	default value USEPA
Exposure Frequency	d/y	32	1 exposure per week for 16 weeks for 2 semesters
Exposure Duration	y	4	exposure duration at a 4 year college
Body Weight	kg	70	default value USEPA
Averaging Time carc.	d	25550	default value USEPA (365 days/year x 70 years)
Averaging Time noncarc.	d	730	value based on 365 days/year for 2 years

Adult recreational surface water dermal contact			
Surface Area	cm3	6360	default value USEPA (surface area of legs and feet)
Exposure Frequency	d/y	32	1 exposure per week for 16 for 2 semesters
Exposure Duration	y	4	exposure duration at a 4 year college
Body Weight	kg	70	default value USEPA
Averaging Time carc.	d	25550	default value USEPA (365 days/year x 70 years)
Averaging Time noncarc.	D	730	value based on 365 days/year for 2 years
Swimming Duration	h/d	1	based on 1 hour duration in water
Permeability Coefficient	cm/h	0.02	chemical specific USEPA Exposure Factor Handbook

Adult recreational surface water inhalation			
Inhalation Rate	m3/d	2.5	default value USEPA Exposure Factor Handbook for moderate activity pattern
Exposure Frequency	d/y	32	1 exposure per week for 16 weeks for 2 semesters
Exposure Duration	y	4	exposure duration at a 4 year college
Body Weight	kg	70	default value USEPA
Averaging Time carc.	d	25550	default value USEPA (365 days/year x 70 years)
Averaging Time noncarc.	d	730	value based on 365 days/year for 2 years

Toxicity Assessment

The toxicity assessment attempts to answer the questions, "What are the main health effects?" and "What levels are safe?" The toxicity values used were based on oral (ingestion), dermal, and inhalation exposure pathways. These values were taken from the preliminary remediation goals (PRGs) for Regions III and IX. Toxiological references referenced in the PRGs come primarily from the Integrated Risk Information System (IRIS) and are shown below. For those chemicals where there is no slope factor or reference dose, that information is either not available, is pending, or the chemical is not considered a carcinogen. For the special case of trichloroethylene, the number has been retracted from IRIS due to the lack of consensus from the scientific community, but it continues to be used due to non-availability of any other data.

Chemical of Concern	Slope Factor (ingestion)	Reference Dose (ingestion)	Slope Factor (oral)	Reference Dose (oral)
Tetrachlorethylene	2.00E-03	1.00E-02	5.20E-02	1.00E-02
Trichloroethylene	6.00E-03	6.00E-03	1.10E-02	6.00E-03
1,1-Dichloroethylene	1.80E-01	9.00E-03	6.00E-01	9.00E-03
Tran-1,2-Dichloroethene		2.00E-02		2.00E-03
Cis-1,2-Dichloroethene		1.00E-02		1.00E-02
Bromodichloromethane	6.20E-02	2.00E-02	6.20E-02	2.00E-02
Chloroform	8.10E-02	1.00E-02	6.10E-03	1.00E-02
1,1-Dichoroethane		1.40E-01		1.00E-01
1,2-Dichloropropane	6.80E-02	1.10E-03	6.80E-02	1.10E-03
Vinyl Chloride	3.00E-01		1.90E+00	
Benzene	2.90E-02		2.90E-02	

Risk Characterization

Risk characterization integrates information from the preceding components of the risk assessment and synthesizes an overall conclusion about the risk. Steps for quantifying risk or hazard indicies for both carcinogenic and noncarcinogenic effects are applied to each exposure pathway and analyzed.

Carcinogenic Effects

For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. The slope factor converts estimated daily intakes averaged over a lifetime of exposure directly to incremental risk of an individual developing cancer. EPA guidance assumes a linear dose-response relationship due to the relatively low exposure levels found at Superfund sites; therefore, the slope factor is a constant, and risk will be directly related to intake. Under this assumption the linear low-dose equation for a single chemical is described below.

$$\textbf{Risk} = \textbf{LADD} \times \textbf{SF}$$

where:
Risk = a unitless probability (e.g., 2.0E-5) of an individual developing cancer
LADD = life time average daily dose averaged over 70 years (mg/kg-day
SF = slope factor, expressed in $(\text{mg/kg-day})^{-1}$

Next, the risk calculated for each chemical of concern is summed together for a total risk per exposure pathway. The cancer risk equation shown below estimates the incremental individual lifetime risk for simultaneous exposure to several carcinogens and accounts for the joint probabilities of the same individual developing cancer as a consequence of exposure to two or more carcinogens.

$$\textbf{Total Risk} = \textbf{Risk}_1 + \textbf{Risk}_2 + \textbf{Risk}_3 \ldots \textbf{Risk}_i$$

where:
Total Risk = the total cancer risk, expressed as a unitless probability
Risk i = the calculated risk for each chemical of concern

Noncarcinogenic effects

The measure used to describe the potential for noncarcinogenic toxicity to occur in an individual is not expressed as the probability of an individual suffering an adverse effect. The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period with a reference dose derived for a similar exposure period. This ratio of exposure to toxicity is called a hazard quotient and is described below.

Noncancer Hazard Quotient = E/RfD

where:
E = exposure level (or chronic daily dose)
RfD = reference dose
E and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term)

The noncancer hazard quotient assumes that there is a level of exposure (i.e., RfD) below which it is unlikely for even sensitive populations to experience adverse health effects. If the exposure level (E) exceeds this threshold (i.e., if E/RfD exceeds unity), there may be concern for potential noncancer effects. The level of concern does not increase linearly as the RfD is approached or exceeded because RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects. Thus, the slope of the dose-response curve in excess of the RfD can range widely depending on the substance.

To assess the overall potential for noncarcinogenic effects posed by more than one chemical a hazard index (HI) approach is used. This approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures. The hazard index is equal to the sum of the hazard quotients as shown below.

$$\textbf{Hazard Index} = \mathbf{E_1/RfD_1 = E_2/RfD_2 = E_i/RfD_i}$$

where:
E_i = exposure level (or chronic daily dose)
RfD_i = reference dose for the *i*th toxicant

When the hazard index exceeds unity (1), there may be concern for potential health effects. While any single chemical with an exposure level greater than the toxicity value will cause the hazard index to exceed unity, for multiple chemical exposures, the hazard index can also exceed unity even if no single chemical exposure exceeds its RfD.

RESULTS

The excess cancer risk and noncancer risk to students was calculated for each chemical and then summed together to determine the total pathway risk and pathway hazardous index. This was done for surface water ingestion, surface water dermal contact, and inhalation of volatiles from surface water. The results for ingestion, dermal contact, and inhalation are displayed below in Tables 1, 2, and 3.

Table 1. Adult Recreational Surface Water Ingestion

Daily Dose (LADD or CDD) = (RME Conc. x IR x EF x ED) / (BW x AT) Carcinogenic risk = LADD x Slope Factor Hazard Quotient = CDD / Reference Dose					
Contaminant	**RME Conc. mg/L**	**Lifetime Average Daily Dose mg/kg/d**	**Chronic Daily Dose mg/kg/d**	**Lifetime Cancer Risk**	**Systemic Hazard Quotient**
Tetrachloroethylene	1.11E-03	7.87E-10	1.38E-08	409E-11	1.38E-06
Trichloroethylene	4.10E-04	2.93E-11	5.14E-09	3.23E-12	8.56E-07
1,1-Dichloroethylene	1.20E-04	8.59E-11	1.50-09	5.15-11	1.67-07
Tran-1,2-Dichloroethene	3.60E-04	2.58E-10	4.51E-09	0.00E+00	2.25E-07
Cis-1,2-Dichloroethene	1.20E-04	8.59E-11	1.50E-09	0.00E+00	1.50-07
Bromodichloromethane	1.40E-04	1.00E-10	1.75E-09	6.21E-12	8.77E-08
Chloroform	1.10E-04	7.87E-11	1.38E-09	4.80E-12	1.38E-07
1,1-Dichoroethane	4.20E-04	3.01-10	5.26E-09	0.00E+00	5.26E-08
1,2-Dichloropropane	1.20E-04	8.59E-11	1.50E-09	5.84E-12	1.37E-06
Vinyl Chloride	1.39E-03	9.95E-10	1.74E-08	1.89E-09	0.00E+00
Benzene	1.80E-04	1.29E-10	2.25E-09	3.74E-12	0.00E+00
Total Pathway Risk				**2.01E-09**	
Pathway Hazard Index					**4.42E-06**

Table 2. Adult Recreational Surface Water Dermal Contact

Daily Dose (LADD or CDD) = (RME Conc. x SA x PC x CD x EF x ED x 1E-3 l/ml) / (BW x AT)
Carcinogenic Risk = LADD x Slope Factor
Hazard Quotient = CDD/Reference Dose

Contaminant	RME Conc. mg/L	Lifetime Average Daily Dose mg/kg/d	Chronic Daily Dose mg/kg/d	Dermal Permeability Coeff. cm/h	Lifetime Cancer Risk	Systemic Hazard Quotient
Tetrachloroethylene	1.11E-03	2.40E-08	4.21E-07	4.80E-02	1.25E-09	4.21E-05
Trichloroethylene	4.10E-04	2.99E-09	5.23E-08	1.60E-02	3.28E-11	8.71E-06
1,1-Dichloroethylene	1.20E-04	8.74E-10	1.53E-08	1.60E-02	5.24E-10	1.70E-06
Tran-1,2-Dichloroethene	3.60E-04	3.28E-09	5.74E-08	2.00E-02	0.00E+00	2.87E-06
Cis-1,2-Dichloroethene	1.20E-04	1.09E-09	1.91E-08	2.00E-02	0.00E+00	1.91E-06
Bromodichloromethane	1.40E-04	3.70E-10	6.47E-09	5.80E-03	2.29E-11	3.23E-07
Chloroform	1.10E-04	4.46E-10	7.80E-09	8.90E-03	2.72E-11	7.80E-07
1,1-Dichoroethane	4.20E-04	1.70E-09	2.98E-08	8.90E-03	0.00E+00	2.98E-07
1,2-Dichloropropane	1.20E-04	5.46E-10	9.56E-09	1.00E-02	3.71E-11	8.69E-06
Vinyl Chloride	1.39E-03	4.62E-09	8.08E-08	7.30E-03	8.78E-09	0.00E+00
Benzene	1.80E-04	1.72E-09	3.01E-08	2.10E-02	4.99E-11	0.00E+00
Total Pathway Risk					**1.07-08**	
Pathway Hazard Index						**6.73E-05**

Table 3. Adult Recreational Ambient Air Inhalation

Daily Dose (LADD or CDD) = (RME Conc. x IR x EF x ED) / (BW x AT)
Carcinogenic risk = LADD x Slope Factor
Hazard Quotient = CDD / Reference Dose

Contaminant	*RME Conc. mg/m3*	*Lifetime Average Daily Dose mg/kg/d*	*Chronic Daily Dose mg/kg/d*	*Lifetime Cancer Risk*	*Systemic Hazard Quotient*
Tetrachloroethylene	1.11E-03	1.97E-07	3.44E-06	3.94E-10	3.44E-04
Trichloroethylene	4.10E-04	7.34E-08	1.28E-06	4.40E-10	2.14E-04
1,1-Dichloroethylene	1.20E-04	2.15E-08	3.76E-07	3.86E-09	4.17E-05
Tran-1,2-Dichloroethene	3.60E-04	6.44E-08	1.13E-06	0.00E+00	5.64E-05
Cis-1,2-Dichloroethene	1.20E-04	2.15E-08	3.76E-07	0.00E+00	3.76E-05
Bromodichloromethane	1.40E-04	2.50E-08	4.38E-07	1.55E-09	2.19E-05
Chloroform	1.10E-04	1.97E-08	3.44E-07	1.59E-09	3.44E-05
1,1-Dichoroethane	4.20E-04	7.51E-08	1.32E-06	0.00E+00	9.39E-06
1,2-Dichloropropane	1.20E-04	2.15E-08	3.76E-07	1.46E-09	3.42E-04
Vinyl Chloride	1.39E-03	2.49E-08	4.35E-06	7.451E-08	0.00E+00
Benzene	1.80E-04	3.22E-08	5.64E-07	9.34E-10	0.00E+00
Total Pathway Risk				**8.48E-08**	
Pathway Hazard Index					**1.10E-03**

DISCUSSION

EPA attempts to manage risks in the range of 1 in 10,000 (1E-4) to 1 in 1,000,000 (1E-6); risk levels below 1 in 1,000,000 are considered *de minimus* or negligible and do not warrant any remedial action. As can be seen in the results above, the total risk per exposure pathway for carcinogenic chemicals does not exceed the action level of 1E-6 nor does the hazard index per exposure pathway for noncarcinogenic exceed unity (1). Therefore, the water is safe. Again these numbers are conservative and are based on limited sampling data. Based on this limited information, the water from Rottenwood Creek poses no significant risk to the students at Southern Polytechnical College.

UNCERTAINTIES

As important as these risk numbers are in the risk assessment, this section would not be complete without a discussion of uncertainty. The uncertainty associated with a risk estimate is primarily the combination of the uncertainties associated with the exposure estimates and the uncertainties in the toxicity evaluation. Additional uncertainty is inherent in environmental sampling, largely because of the potential for uneven distribution of chemicals in the environmental media.

Risk associated with the future exposure pathways are only meaningful if the pathways are completed. For surface water pathway, such as found in Rottenwood Creek, the probability is very low that students will come in direct contact with the water for extended periods of time, be immersed in water up to their waists, or be able to swim in the creek. The other physiological parameters that are used come from the default assumptions that are published by the EPA in its Exposure Factors Handbook and may not necessarily reflect the exact make up of the student population, and are at best estimates based on statistical data.

There is also considerable uncertainty associated with the toxicity of mixtures. For the most part, the toxicities of constituent mixtures are unavailable. Rather, toxicity studies generally are performed using single constituents. By summing or adding the risk of each chemical to develop a total risk per exposure pathway, the tendency at low levels of exposure is to overstate the amount of risk.

The most significant uncertainties are associated with the toxicity values slope factors and reference doses. Toxicity values are derived from animal study data. Animals are exposed to large doses of chemicals to produce some effect. Resultant data is then extrapolated to predict a human response. However, humans are generally exposed to concentrations many orders of magnitude less and may not exhibit the same, if any, effect.

Finally, the limited availability of data for use in this risk assessment makes it difficult to feel certain that it represents the level of possible contaminants that would be found over time at the site. To reduce this uncertainty, additional sampling is necessary.

RECOMMENDATIONS

As a result of the above evaluation, we believe that no further action is required at this time. However, due to the potential for accidental discharge into Rottenwood Creek from AFP 6, we suggest that monitoring of those chemicals of potential concern be incorporated or continued in future sampling activities.

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1. U.S. Environmental Protection Agency, Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part 1), Interim Final, Office of Emergency and Remedial Response, Washington, D.C., December 1989b.

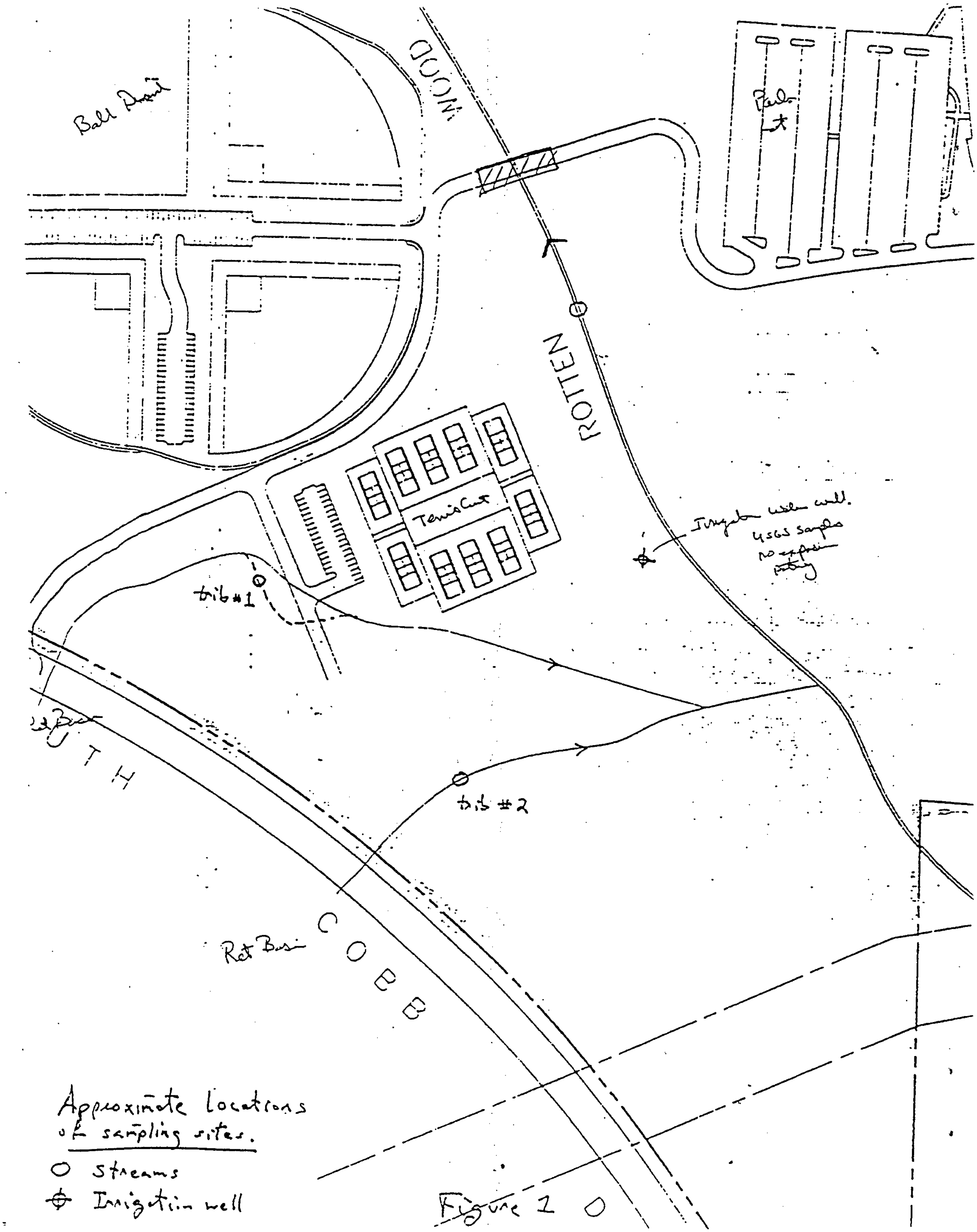
2. U.S. Environmental Protection Agency, Region 4, Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment, Office of Emergency and Remedial Response, Atlanta, GA, November 1995.

3. U.S. Environmental Protection Agency, Region IX Preliminary Remediation Goals (PRGs) Second Half 1994, August 1, 1994

4. U.S. Environmental Protection Agency, Region III Preliminary Remediation Goals (PRGs) Second Half 1994, July - December 1995

5. National Research Council (NRC), Complex Mixtures, National Academy Press. Washington D.C., 1988.

Appendix 1. Sampling Locations Along Rottenwood Creek and Tributaries



Ball Pond
WOOD
Park lot
ROTTEN
Tennis Court
Irrigation water well. USGS samples no exposure potty
trib #1
trib #2
Ret Basin
COBB
Approximate locations of sampling sites.
O streams
Irrigation well
Figure 1

Appendix 2: Historical Data, for Irrigation Well and Nearby Tributaries

Table 1. Concentrations of VOCs Detected in Water from Southern Technical Irrigation Well and in Nearby Streams

Sampling site	Sampling ID	Sampling date/time	Tetrachloroethylene	Trichloroethylene	1,1-Dichloroethylene	Trans-1,2-Dichloroethylene	Cis-1,2-Dichloroethene	Bromodichloromethane	Carbon Tetrachloride	Chloroform	1,1-Dichloroethane	1,2-Dichloropropane	Vinyl Chloride	1,2-dichlorobenzene	Benzene
Southern Tech Irrigation Well	1	12/20/1994 1240	11.12	280	0.46	0.27	5.83	nd	0.01	0.88	0.17	nd	nd	0.15	nd
Southern Tech Irrigation Well	2	12/20/1994 1248	14.41	440	0.54	0.3	6.29	nd	0.12	0.94	nd	nd	nd	0.15	nd
Southern Tech Irrigation Well	3	12/20/1994 1254	10.95	340	0.41	0.27	5.5	nd	0.1	0.79	0.17	nd	nd	0.13	nd
Rottenwood Creek at Southern Tech below bridge near well		12/20/1994 1328	**1.11**	**0.41**	nd	nd	**0.12**	nd	nd	**0.11**	nd	nd	nd	nd	nd
Rottenwood Creek Tributary 1 above well site		12/20/1994 1350	nd	8.12	**0.12**	**0.36**	11.73	**0.14**	nd	0.48	**0.42**	**0.12**	**1.39**	nd	nd
Rottenwood Creek Tributary 2		12/20/1994 1400	0.11	16.6	nd	0.12	8.01	nd	nd	nd	nd	nd	0.12	nd	**0.18**

Note: Concentrations in micrograms per liter (ug/L); nd, not detected
Bolded concentrations indicate values used in risk calculation